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DESCRIPTION

ELECTROSTATIC ATOMIZER AND AIR PURIFIER USING THE SAME

TECHNICAL FIELD

The present invention relates to an electrostatic atomizer for emitting a liquid in the form of tiny ionized particles and an air purifier using the same.

BACKGROUND ART

Japanese Patent Publication 2002-203657 discloses a prior art electrostatically atomizing device. The electrostatically atomizing device includes a nozzle dropping or spraying the water into a discharge compartment, and an electrode opposed to the nozzle. A high voltage is applied between the nozzle and the electrode to emit the positively charged water particles from the tip of the nozzle. The water is supplied from a container mounted outside of the discharge compartment. In order to keep the electrostatic atomization over a long period of use, the water has to be regularly replenished to the container, rendering the maintenance annoyance.

DISCLOSURE OF THE INVENTION

The present invention has been achieved to overcome the above problem, and to provide an electrostatically atomizing device and an air purifier using the same which is capable of maintaining stable electrostatic atomization over a long period of use.

The atomizing device in accordance with the present invention includes a carrier carrying the liquid to be atomized, and a liquid storing means storing a volume of the liquid. The carrier is configured to have a liquid collecting end and a discharge end opposite thereto, the liquid collecting end being immersed in the liquid for feeding the liquid to the discharge end. The device includes a first electrode for electrically charging the liquid, and a second electrode opposite to the discharge end, and a voltage source. The voltage source applies a high voltage between the first and second electrodes so as to charge the liquid at the

discharge end, thereby discharging the liquid in the form of tiny ionized particles. The liquid storing means is accommodated within a housing together with the carrier, the first and second electrodes, and the voltage source. The feature of the present invention resides in that at least a part of the liquid storing means is detachable to the housing. Thus, the part of the liquid storing means detachable to the housing can be utilized to replenish the liquid without difficulty.

In a preferred embodiment, the liquid storing means is composed of a reservoir mounted within the housing, and a replenishing tank supplying the liquid into the reservoir. The replenishing tank is detachable to the reservoir and is utilized for easy replenishing of the liquid.

Preferably, the reservoir, the carrier, the first electrode, the second electrode, and the replenishing tank are accommodated within a recess formed in the housing. The housing has a lid covering the recess, and a switch is provided to stop applying the high voltage from the voltage source upon opening of the lid. Thus, while replenishing the liquid with the lid opened, the high voltage is not applied to the liquid in the reservoir. Consequently, when the liquid or the electrodes are touched by mistake, the human body can be protected from the high voltage, assuring safe replenishment of the liquid.

In a preferred embodiment, the first and second electrodes are detachably connected respectively to first and second contacts which are accommodated within the housing together with the voltage source. The carrier, the first and second electrodes are accommodated together with the reservoir within a casing which is detachable to the housing. Thus, when the reservoir and the carrier are required to be cleaned, the casing is detached from the housing to make required treatment.

In this case, it is preferred that the housing includes a recess for accommodating the casing and a lid is provided to cover the recess, and that a switch is provided to stop applying the high voltage from the voltage source upon opening of the lid. The recess is preferably is sealed from the interior of the housing to avoid the leakage of the liquid for protection of the voltage source

within the housing from the liquid.

The first and second electrodes are mounted in a barrel together with the carrier. The first and second electrodes are provided respectively with first and second terminals for pressed contact with the first and second contacts of the voltage source. The first and second terminals are preferred to be disposed on opposite sides of the barrel to receive from the first and second contacts respectively with contacting forces that counterbalancing with each other. With the counterbalancing forces, the first and second terminals are brought into firm electrical contact respectively with the first and second contacts, thereby assuring the reliable electrical connection between the voltage source in the housing and the first and second electrodes in the casing, while making the casing detachable to the housing.

The electrostatically atomizing device thus configured is preferably incorporated in an equipment such as an air purifier. The air purifier has a housing equipped with a contaminant trapping filter, and a fan circulating the air through the filter. The atomizing device is disposed in the housing downstream of the fan and the filter. Thus, the tine ionized liquid particles as well as negative ions generated from ionizing needle can be carried on the clean air removed of the contaminants through the filter so as to be spread into a room space, giving deodorant effect and/or other environment improving effect of the particles over a wide space of the room.

These and still other objects and advantageous features will become apparent from the detailed explanation of the preferred embodiment when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section of an electrostatically atomizing device in accordance with one embodiment of the present invention;

FIG. 2 is a schematic view illustrating the operation of the above device;

FIG. 3 is a top view of an electrode plate utilized in the above device;

FIG. 4 is a cross-section of an air purifier incorporating the above device;
FIG. 5 is an exploded perspective view of a portion of the above device; and
FIG. 8 is a cross-section illustrating an electrostatically atomizing device in accordance with another embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

An electrostatically atomizing device **M** in accordance with one embodiment of the present invention is configured to ionize particulate water, for example, so as to generate ionized water particles of a nanometer. As shown in FIG. 1, the atomizing unit **M** includes a base **10** supporting a plurality of capillary carriers **20**, a barrel **30** surrounding the top of the base **10**, an electrode plate **40** fitted in the top opening of the barrel **30**, and a reservoir **50** attached to the lower side of the base **10**. The base **10** and the reservoir **50** are accommodated within a casing **90** together with a replenishing tank **80** detachable to the reservoir **50**. The casing **90** is accommodated within a recess **120** that is formed in a housing **101** of an air purifier **100**, as shown in FIG. 4. In the present embodiment, the reservoir **50** and the replenishing tank **80** are cooperative to define a liquid storing means for storing the liquid to be supplied to capillary carriers **20**. The recess **120** is sealed from the interior of the housing **101** to protect the high voltage source **70** from the water, in case the water leaks in the recess **102**.

Each of the capillary carriers **20** is made from porous ceramic and shaped into a porous bar having a diameter of about 5 mm and a length of about 70 mm, and extending through the base **10**. The carrier **20** is formed with a discharge end **21** at its pointed end of a portion projecting on top of the base **10**, and with a liquid collecting end **22** at its portion projecting on the underside of the base **10**. The liquid collecting end **22** is immersed in the water in the reservoir **50** to suck up the water and feed it to the discharge end **21** by the capillary action. The base **10** is made of an electrically conductive plastic material and acts as a first electrode giving negative electrical potential to each

capillary carrier **20**. For this purpose, the base **10** is formed at its periphery with a first terminal **12** for connection with negative side of the high voltage source **70**.

The high voltage source **70** is configured to apply the high voltage having an electric field strength of 500 V/mm, for example, between the base **10** and the electrode plate **40**, developing an electrostatic atomization between the discharge end **21** at the distal end of the capillary carrier **20** and the electrode plate **40** defining the second electrode opposing the discharge end, such that tiny ionized water particles are emitted from the discharge end **21** towards the electrode plate **40**. That is, the high voltage induces Rayleigh disintegration of the water being emitted from the discharge end, thereby generating negatively-charged water particles and emitting the mist of the tiny ionized water particles. In the present embodiment, the electrode plate **40** is connected to a ground potential so as to give a predetermined voltage difference relative to the negative potential given to the base **10**. The high voltage source **70** applies a continuous or pulses of the high voltage between the electrode plate **40** and the base **10**.

The electrode plate **40** is molded from an electrically conductive resin and shaped to have a circular outer periphery with a center opening having a star-shaped opening circumference **41**. The opening circumference is held in closely opposed relation to the discharge end **21** of each carrier **20** to develop a discharge between the opening circumference **41** and the discharge ends **21**. The electrode plate **40** is formed at its periphery with a second terminal **48** for connection with the positive side of the high voltage source **70**. The first terminal **12** and the second terminal **48** are configured to come into pressed contact respectively with first and second contacts **71** and **72** that are connected respectively with the positive and negative sides of the voltage source **70**.

The barrel **30** is formed in its outer wall with a plurality of windows **32** through which the air is introduced to make an air flow directed outwardly of the center opening of the electrode plate **40**. The negatively ionized tiny water

particles generated between the discharge ends **21** and the electrode plate **40** are carried on the air flow so as to be emitted in the form of a mist into a wide space. As shown in FIG. 4, since the electrostatically atomizing device **M** is incorporated in the air purifier **100**, the forced air flow generated at the air purifier **100** is best utilized to scatter the tiny ionized water particles over wide range. The housing **101** of the air purifier **100** has an air inlet **102** and an air outlet **104**. A fan **110** and a filter **112** entrapping the dust and other contaminants are accommodated within the housing **101** so as to draw the outside air through the filter **112** and flow the clean air out of the air outlet **104**. The electrostatically atomizing device **M** is disposed adjacent to the air outlet **104** downstream of the filter **112** and the fan **110**.

The base **10** supports at its center an ionizing needle **60** which has a pointed tip projecting upwardly of the base in alignment with the discharge ends of the capillary carriers **20** and which is electrically charged to the same potential as the capillary carriers **20**. The capillary carriers **20** are evenly spaced in a circle concentric to the ionizing needle **60**. The opening circumference **41** of the electrode plate **40**, which define the opposed electrode commonly to the capillary carriers **20** and the ionizing needle **60**, is defined by a combination of a plurality of curved edges **42**. Each of the curved edges is a semi-circular edge about the discharge end **21** of each corresponding capillary carrier **20** leaving a constant distance with the discharge end **21**. The adjacent curved edges **42** define therebetween a second edge **44** that is opposed to the ionizing needle **60** to bring about a corona discharge therebetween, thereby negatively charging molecules such as oxygen, oxide, or nitride in the air to generate negatively charged ions, while restraining the generation of ozone. The distance R2 between the second edge and the ionizing needle **60** is made greater than the distance R1 between the first curved edge **42** and the discharge end **21**, such that the atomization of the liquid at the discharge end **21** and the generation of the negatively charged ions at the ionizing needle **60** can be done respectively at optimum conditions.

The reservoir **50** is horizontally elongated to provide a connection port **52** which is formed in top of a side extension from the barrel **30** to detachably receive a spout **82** of the replenishing tank **80**. The spout **84** includes a valve **84** which opens in response to the insertion of the spout **82** into the connection port **52** for replenishing the water from the tank **80** into the reservoir **50**..

The base **10** carrying the capillary carriers **20** and the barrel **30** surrounding the top of the base **10** are integrated with the reservoir **50**, and are retained together with the replenishing tank **80** within the casing **90**. The recess **120** of the housing **101** configured to detachably receive the casing **90** is provided with a lid **130**. With the lid **130** being opened, the replenishing tank **80** is attached to or detached from the reservoir **50**, in addition to that the casing **90** is attached to or detached from the recess **120**. The lid **130** is made of a perforated pate to define the air outlet **104**. Disposed around the periphery of the recess **120** is a proximity switch **140** that stops the high voltage source **70** or interrupts the electrical connection from the high voltage source **70** to the first and/or second terminals **71** and **72** in response to the opening of the lid **130**. Thus, the high voltage can not be applied to the capillary carriers **20** and the water in contact therewith , assuring safe attachment and detachment of the replenishing tank **80** or the casing **90**, or safe inspection of the interior of the device.

The first contact **71** and the second contact **72** are each shaped into a metal spring leaf in order to make the electrical connection respectively with the first terminal **12** and the second terminal **48** by the spring pressure. As shown in FIG. 5, the contacting areas of the first contact **71** and the second contact **72** are each rectangular and has a width (W1) greater than the width (W2) of the first terminal **12** and the second terminal **48**. Thus, the first terminal **12** and the second terminal **48** made of the electrically conductive plastic material are prevented from being scraped off by the edge of the spring leaves at the time of attachment or detachment of the atomizing device **M**, keeping reliable electrical connection.

Each of the capillary carriers **20** is made of the porous ceramic material of particle size of 2 to 500 μm and has a porosity of 10 to 70 % to feed the water to the discharge end **21** by the capillary effect using minute paths in the ceramic. The ceramic is selected from one or any combination of alumina, titania, zirconia, silica, and magnesia, and is selected to have a PH at the isoelectric point lower than PH of the water in use. The basis of such selection is related to mineral components such as Mg and Ca possibly contained in the water being utilized. The mineral components contained in the water are refrained from advancing to the discharge end of the capillary carrier **20** and therefore refrained from reacting with CO_2 in the air to precipitate as MgO or $CaCO_3$ which would otherwise impede the electrostatic atomization effect. That is, the electroosmotic flow in the capillary carriers **20** can be best utilized so that Mg or Ca ions dispersed in the water is prevented from advancing to the discharge end **21**.

When the mist of the tiny ionized water particles caused by the electrostatic atomization is generated at a rate of 0.02 ml/m within an electric field strength of 500 V/mm or more with the use of the capillary carrier **20** of which tip diameter is 0.5 mm or below, the mist contains the very fine ionized particles having the nanometer particle size of 3 to 100 nm, which react with the oxygen in the air to give the radicals such as hydroxyl radicals, superoxides, nitrogen monoxide radicals, and oxygen radicals. The mist of the tiny ionized water particles, when released into a room, can deodorize substances contained in the air or adhered to the walls. The following are reaction formulas between the radicals and various kinds of odor gases.

ammonia :	$2NH_3+6 \cdot OH \rightarrow N_2+6H_2O$
acetaldehyde :	$CH_3CHO+6 \cdot OH+O_2 \rightarrow 2CO_2+5H_2O$
acetic acid :	$CH_3COOH+4 \cdot OH+O_2 \rightarrow 2CO_2+4H_2O$
methane gas :	$CH_4+4 \cdot OH+O_2 \rightarrow CO_2+H_2O$
carbon monoxide :	$CO+2 \cdot OH \rightarrow CO_2+4H_2O$
nitrogen monoxide :	$2NO+4 \cdot OH \rightarrow N_2+2O_2+2H_2O$
formaldehyde :	$HCHO+4 \cdot OH \rightarrow CO_2+3H_2O$

FIG. 6 illustrates another embodiment of the present invention which is basically identical to the above embodiment except that the first terminal **12** and the second terminal **48** are disposed on diametrically opposed ends so as to approximately counterbalance the spring forces, one acting from the first contact **71** to the first terminal **12**, and the other acting from the second contact **72** to the second terminal **48**. Thus, the sufficient contacting pressure can be obtained at the respective connections to make the reliable electrical connection of the high voltage source **70** to the base **10** and the electrode plate **40**. The like parts are designated by like reference numerals.

Although the above embodiment is explained with reference to an example in which the water is utilized to generate mist of the tiny ionized water particles, the present invention is not limited to the particular embodiment, and can be applicable to the use of the various liquids other than the water. The available liquid includes the water containing valuable components such as vitamin C, amino acids, a deodorant such as fragrant oil or aromatic, and includes a colloidal solution such as a make-up lotions.